PMI Studies of Lithium

Presented by
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with contributions from
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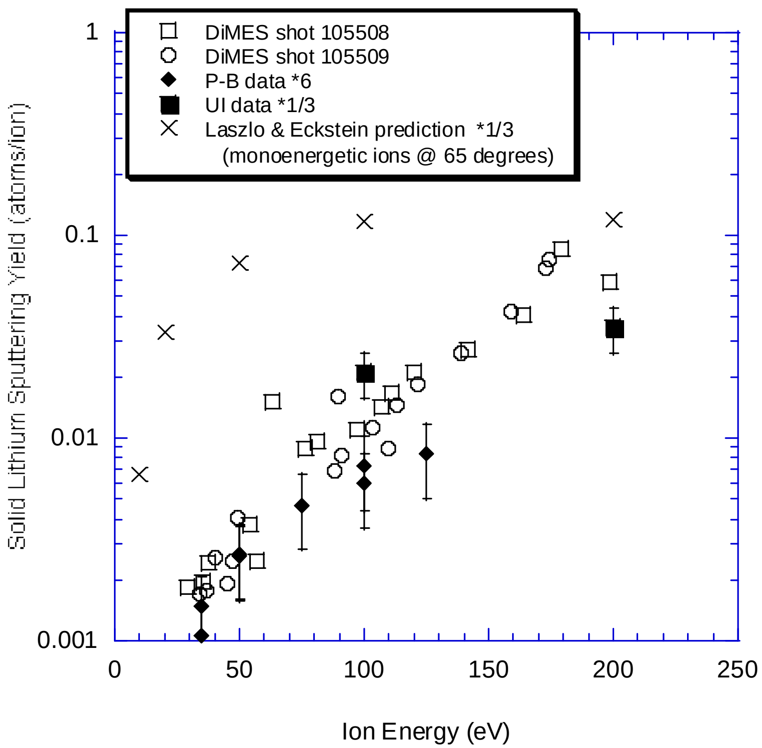
as well as the PISCES, CDX-U and DiMES Teams

- Mechanisms for material loss from lithium plasma-facing components
- Hydrogen/deuterium interactions with, and retention in, liquid lithium

Neutral lithium atom sputtering yield from solid lithium shows good agreement between DiMES, PISCES-B and IIAX data, but less than predicted.

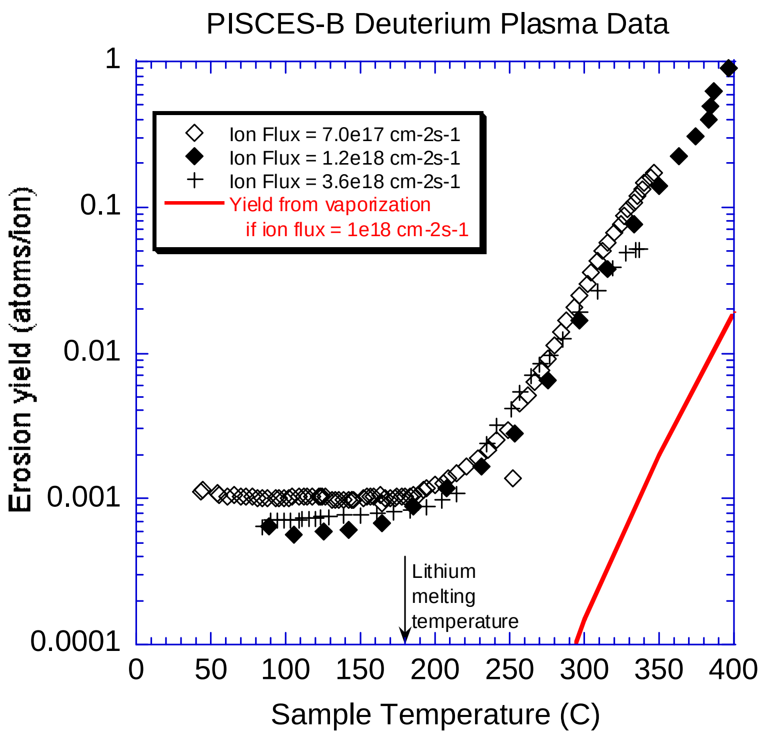
- In order to compared measured yields, they are normalized to show expected Lithium yield vs. D^+ incident energy at ~45-60° angle of incidence
  - DiMES: T_e *5 = E_{ion}
  - PISCES-B: Yield *6 (from L&E angular dependence data)
  - IIAX: Yield *1/3 (neutral sputtered fraction)



- Comparing material loss rates from liquid lithium samples is still a challenge

Erosion yield of liquid lithium depends on sample temperature.

- PISCES-B data shows a strong temperature dependence of erosion yield above 200°C
- University of Illinois (IIAX) data shows little difference between sputtering from solid and liquid (at 200°C) targets
- Difficulty keeping DiMES sample stationary inhibits measurements during the liquid phase

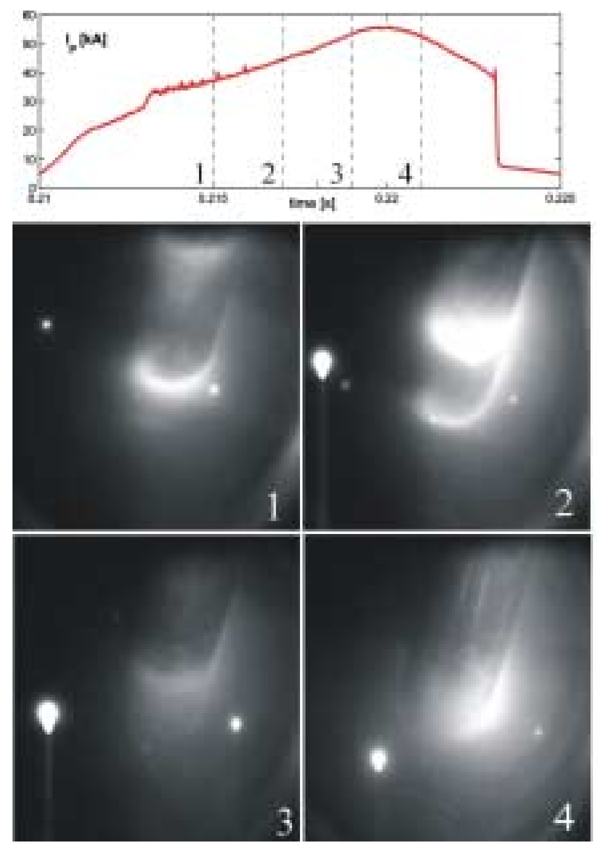


Current flow from the plasma (JxB) into conducting plasma-facing component may prove to be the most restrictive constraint on the use of liquid metals.

- JxB dominates the forces in the lithium on the CDX-U limiter and may be responsible for the ejection of droplets into the plasma

- During liquid lithium DiMES exposure, the JxB force may result in the propulsion of the entire lithium sample into the core

- Non-normal incidence magnetic field experiments are being implemented in PISCES



Retention of Deuterium in Liquid Lithium

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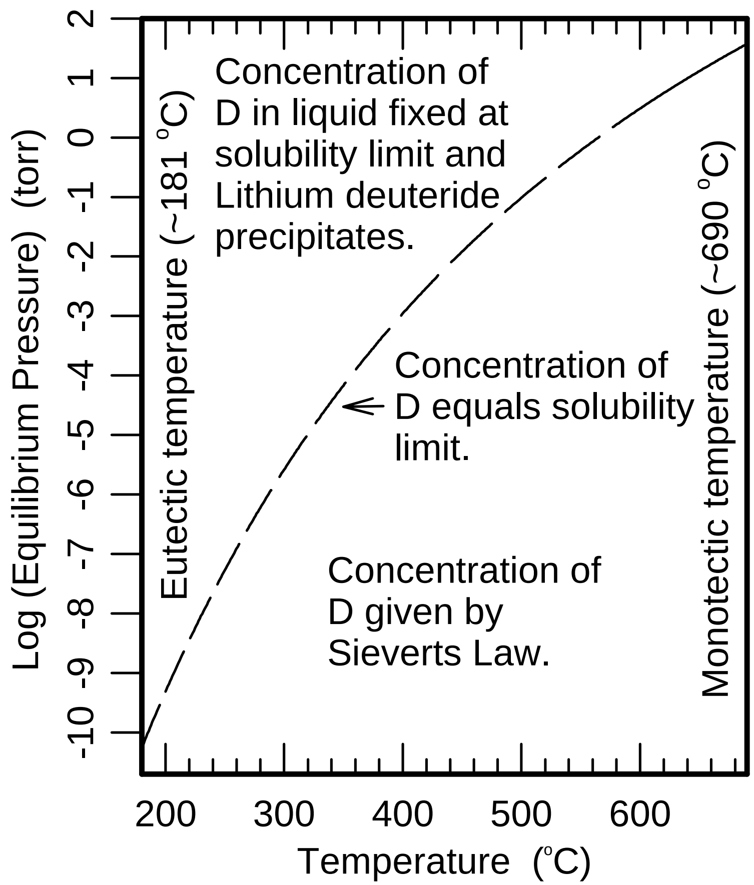
Decomposition pressure for Li-LiD.

- Figure shows Li-LiD decomposition pressure between eutectic and monotectic points on the Li-LiD phase diagram. Data are extrapolated down to 180 ºC using results of : Veleckis E (1979) *J. Nucl. Mater.* 79 20-7.



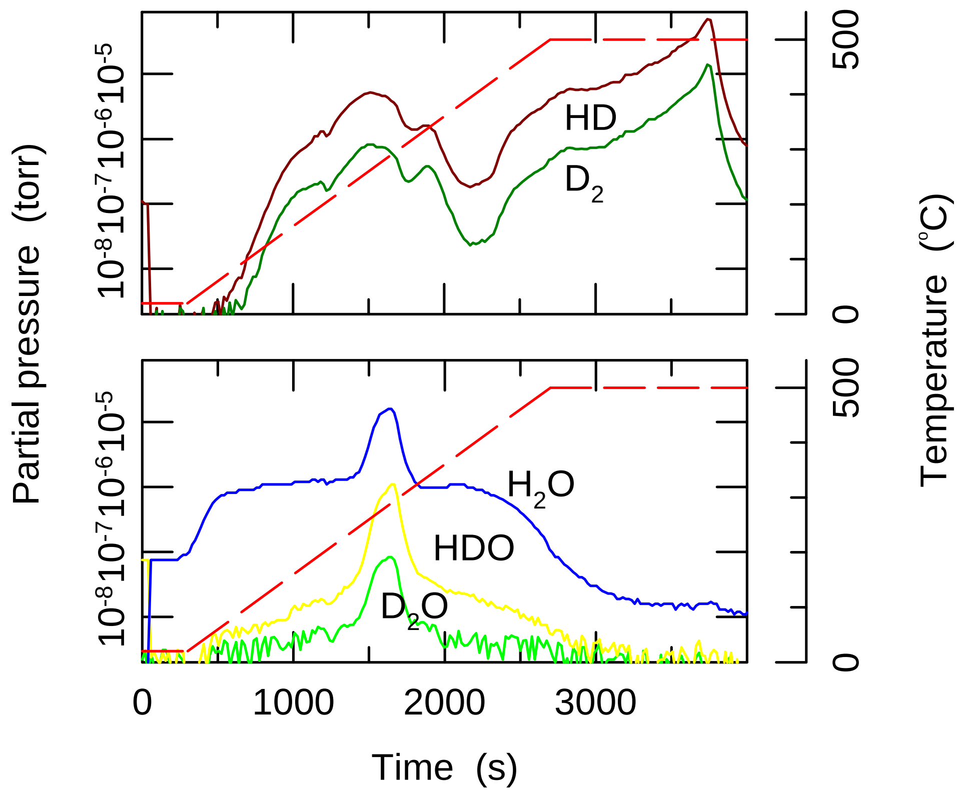
PISCES plasma exposure parameters.

- Samples of Li were exposed to deuterium plasma over a wide range of temperatures and ion fluence.

Parameter	
Ion flux ($cm^{-2}s^{-1}$)	10^{17}–10^{18}
Ion energy (bias) (eV)	50–100
Ion fluence (cm^{-2})	~10^{20}–10^{22}
Sample temperature (°C)	40–400
Target materials	Solid and Liquid Li
Plasma species	D

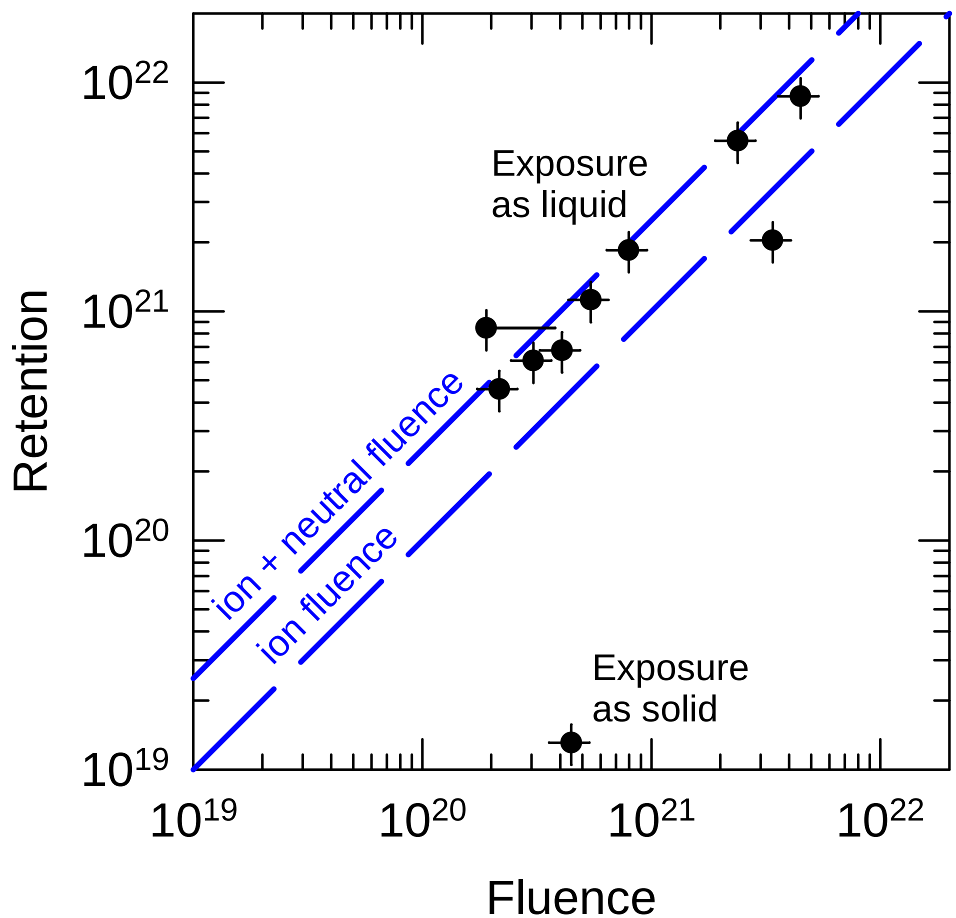
Retained D was measured using calibrated Thermal Desorption mass Spectrometry (TDS) .

- Subsequent to exposure in PISCES each sample is out-gassed at temperatures up to 500 ºC.
- This procedure involves fully evaporating all of the lithium from the sample holder.



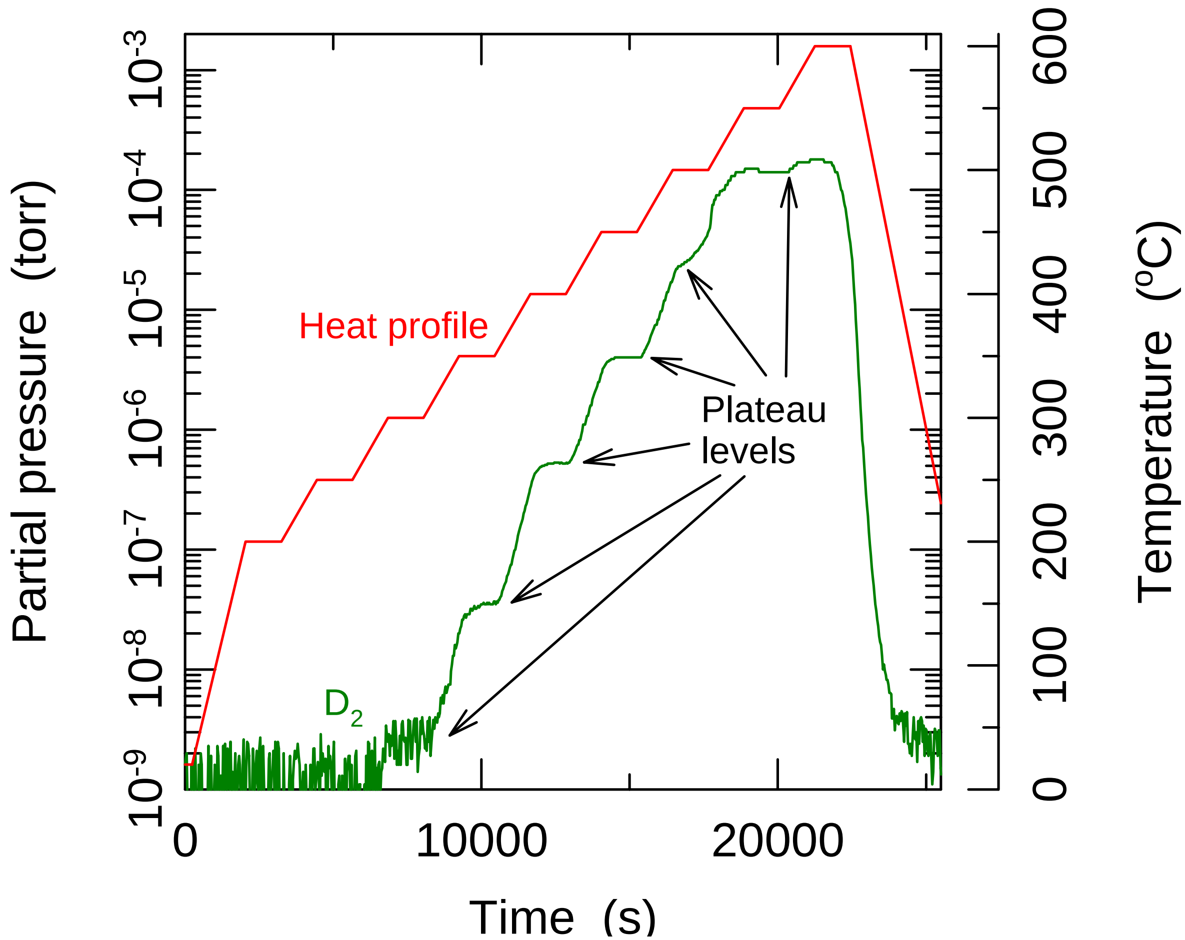
D Retention in liquid lithium exceeds 100 % of the incident ion fluence.

- Retained D at levels above 100% of the ion fluence indicate an additional source of species that the liquid Li will react with.
- Estimates of neutral atom flux due to charge exchange dissociation can account for the extra retained D.
- A liquid Li sample exposed to neutral D_2 molecules did not show any appreciable D uptake.



Controlled out-gassing may allow measurement of the deuterium recombination rate *K*.

- $J = Kc^2$
  where J is the net flux of D atoms from the surface, and c is the concentration of D at the surface.



Concluding remarks

- We have experimentally observed large retention of hydrogen (>100 %) in liquid lithium by performing TDS on samples of Li exposed to a wide range of plasma ion fluences.
- Levels of retained D exceed the ion fluence. Initial estimates of neutral atom flux in PISCES due to charge exchange / dissociation seem to account for the extra retained D. A liquid Li sample exposed to neutral D_2 molecules did not show any appreciable D uptake.
- Similar measurements of He retention in liquid Li will soon commence.
- We are also exploring the possibility of using our TDS measurements to extract a measurement of the recombination rate for deuterium atoms at the sample surface.